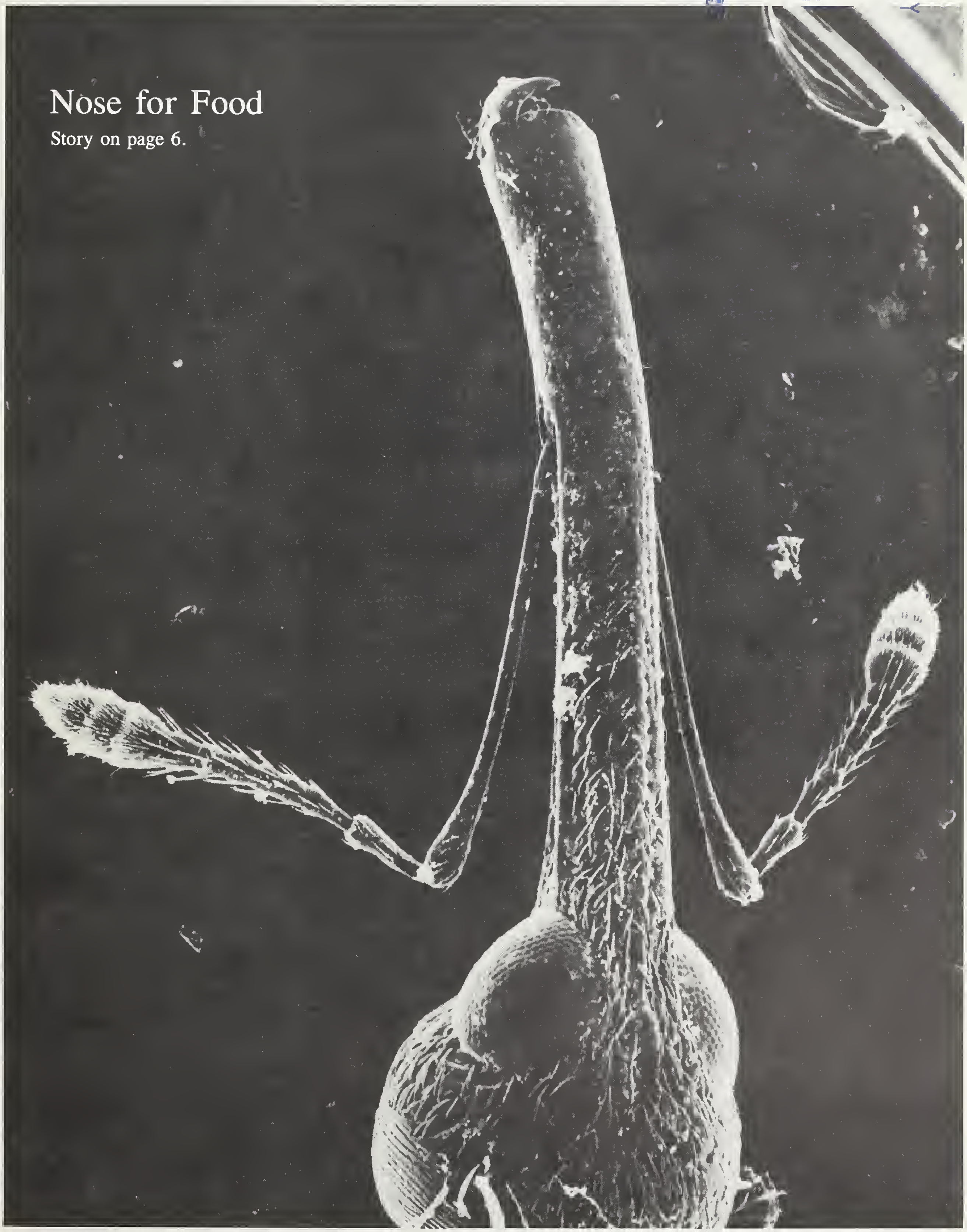
U.S. Department of Agriculture Agricultural Research Service Vol. 34, No. 9, October 1986

Agricultural Research



Nose for Food

Story on page 6.

Breaking the Time Barrier

Think what it would mean to solve a vexing agricultural problem in years rather than decades. To know what to do about a crop disease now rather than later could save millions of bushels of grain or pounds of produce for a farmer. It could mean the difference between a profitable operation and a foreclosure.

Few could argue that sooner isn't better than later when it's a pest that is destroying a crop or erosion robbing the land of its productive ability.

But can science be hurried? No, not in the strictest sense, because the solution to a problem only follows a process where data is painstakingly collected, compiled, analyzed, reviewed, and replicated. Some of the steps in this process, however, can be shortened dramatically by imaginative researchers.

Consider, for example, the Sunhigh—a tasty, free-stone peach grown in the eastern United States. Bacterial leaf spot disease has taken the Sunhigh variety off the market.

The conventional approach to this problem would be to plant peach seeds and expose the young seedlings to leaf spot bacterium until one was found to be resistant—a procedure that could span years and occupy acres of greenhouse or orchard space.

An innovative researcher at the Beltsville (Maryland) Agricultural Research Center found a way to speed up the search by testing millions of peach cells in a laboratory growth medium laced with toxin from the bacterium.

The successful experiment was a first for producing a disease-resistant tree from a disease-susceptible variety and took less than a year in laboratory space not much larger than a refrigerator shelf.

Another scientist at Beltsville slashed the time needed to develop rice with a more nutritious protein. He did it by using a chemical that killed all rice pollen cells that had low levels of lysine, an essential amino acid. The chemical selection eliminated a random search through hundreds of thousands of rice plants. After developing the technique, his actual search for a better rice took only 2 years, compared with the usual 5 or 6 needed for traditional selection techniques.

Another way to hurry research is to grow only the part of a plant that is under study. In experiments partially funded by ARS, a Texas Tech University researcher found a way to grow cotton fibers in a test tube without any other part of the plant. This isolation of one plant part allows scientists to avoid a lot of distracting variables (insects and the weather for example), and it gives them a steady, year-round supply of plant material for research.

Not that biotechnology is the only way to speed up plant work. An ARS scientist in California found a way to hasten traditional breeding techniques. An ingenious idea came to the scientist when he noticed that some lettuce plants were bypassing the leaf production stage and producing flowers in about 50 days, instead of the usual 120 days. Since the early flowering is caused by a partially dominant gene, why not use only plants with that gene when breeding for a desired trait? The speedy gene would shorten each plant's generation by about 70 days and could be bred out once the trait was transferred. Using this technique, the scientist expects to transfer lettuce mosaic disease resistance into Prizehead lettuce, a susceptible commercial variety, in about 550 days rather than the usual 875.

Time-and-space-saving techniques aren't limited to the plant world. Imagine sitting in a lab office and at the punch of a computer button being able to weigh a cow or take her temperature while she drinks water 5 miles away! That's what ARS scientists are doing in Montana and New Mexico.

The computerized weighing system uses electronic devices to open a gate that allows only one cow to enter at a time for a quiet drink at the trough. The cow doesn't even realize she is standing on a scale.

The computer that receives the weights by radio is one of many used by ARS scientists. Computers analyze in seconds what would take a person hours to months.

Computers are now used to simulate natural processes over months, years, decades, and centuries in a matter of minutes or hours. For example, an ARS team working with an economist from USDA's Economic Research Service put together a computer model, EPIC (Erosion-Productivity Impact Calculator), that can recreate the subtle process by which erosion slowly robs soil of its ability to grow a crop over a period as long as several hundred years. The simulations can replace field research that often took several years, even decades, to complete.

The list of uses for computers and other new time-saving technologies is long and covers the full range of research from insect neurochemistry to plant and animal genetics to human nutrition needs. The limitations of time, funding, and working space often give way when ARS ingenuity is applied to these technologies.—**Don Comis,** ARS

Agricultural Research

Cover: Antennae of the cotton boll weevil are mounted on the sides of its snout. As with other insects, the boll weevil relies on antennae and other body parts for its sense of smell. Story begins on page 6. (Magnification 60 times. Scanning electronmicrograph by Joseph Dickens. PN-7209)

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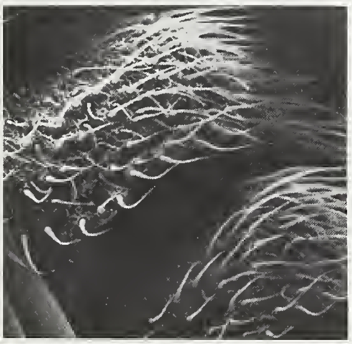

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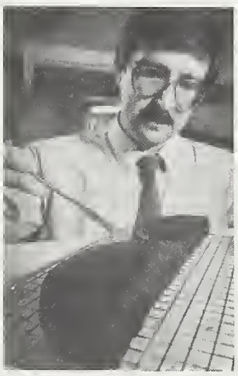

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DEPARTMENTS

Vol. 34, No. 9
October 1986

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Agricultural Research is published 10 times per year by the Agricultural Research Service (ARS), U.S. Department of Agriculture, Washington, DC 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, DC 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by month and photo number.

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Exploded Mushrooms: Gourmet Food or Snack

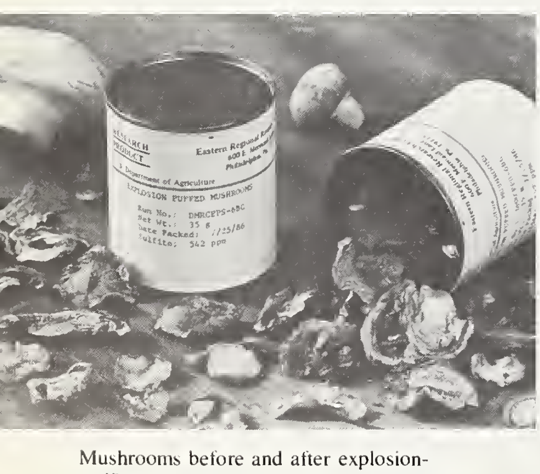
Mushrooms can now be "puff-dried," stored indefinitely, and then cooked in boiling water, while retaining their flavor and texture. Uncooked, the mushrooms can be eaten as a new snack that is tasty, nutritious, and low calorie, says a scientist for USDA's Agricultural Research Service.

"Puff-dried mushrooms are of higher quality than those conventionally dried," says Michael Kozempel, a chemical engineer at the agency's Eastern Research Center in Philadelphia. "They retain more nutrients, especially B vitamins, and are easy to rehydrate."

"I foresee one very popular use as a dry product," he says, describing the low-calorie, puff-dried mushroom bits as "crunchy, something like croutons people sprinkle on salads."

Unlike conventionally dried mushrooms that are flat, hard flakes, explosion-puffed mushrooms have a porous texture that allows them to take up water rapidly. Popping them into boiling water for 5 minutes makes them suitable as a food condiment or an ingredient in soups.

In the puff-drying system, high air pressure is exerted on batches of mushrooms. When the pressure is suddenly released, the "moisture inside them literally explodes," says John Sullivan, a chemical engineer who with mechanical engineer Wolfgang Heiland developed explosion puffing of fruits and vegetables at the Philadelphia center.



Mushrooms before and after explosion-puffing. End product is a tasty, nutritious snack whether eaten 'as is' or rehydrated in boiling water. (0986X1036-34)

The process can save 40 percent of the energy required in conventional food-drying systems.—By **Stephen Berberich,** ARS.

Michael Kozempel and Wolfgang Heiland are at the USDA-ARS Eastern Research Center, 600 East Mermaid Lane, Philadelphia, PA 19118. John Sullivan is now retired. ■

Vapor-Locked Plants Resist Freezing

Even at subzero temperatures, parts of some plants simply refuse to freeze. Uniquely arranged microscopic pores and vessels inside the plants may be what protects them, according to a USDA Agricultural Research Service scientist.

"Based on preliminary studies, I believe a few plants, like the plum tree, may resist freezing because the pores and vessels that connect the stems and flowers have the ability to stay dry," says John W. Cary, who recently retired from the agency. "Although it is still a theory, it's one of the more intriguing things I've found in my 30 years of research.

"No one knows what the best arrangement of these tiny pores and vessels is," says Cary. "But we do know certain plant flowers—like plums, wild violets, and wild currants—naturally tolerate freezing.

"If we could transfer this type of protection to frost-prone crops," he says, "we could greatly expand the area now used to grow produce of all kinds. Breeding plants to change the arrangement and distribution of tissue pore size may be a key to reducing a plant's vulnerability to frost.

"But a lot of research still has to be done," he says. "It could take 15 or 20 years to breed frost-resistance into plants."

Cary's findings run counter to those of other researchers who have speculated that a special membrane somewhere in the plum bud may prevent ice from forming in—and destroying—the plum ovary.

"My theory," says Cary, who until June was a soil scientist at the Snake River Conservation Research Center in Kimberly, ID, "is based on the special arrangement of pores and vessels in the plum tree. This arrangement allows water in the plum flower to flow away from the base of the ovary because it is attracted to ice crystals that have already formed nearby—in the stem. These crystals draw water, much like a blotter.

"This leaves a dry, dehydrated area in the base of the ovary," says Cary. "The dry pores and vessels surrounding the ovary are filled with vapor instead of liquid. This stops more water from entering the ovary area—even if temperatures drop 8 or 10 degrees below freezing.

"It's like a vapor lock that forms in your car's fuel line and keeps gas from entering the engine," says Cary. "In the plum, the result of this vapor lock is that the ovary, now shielded from freezing, remains fertile and able to form fruit."
—By **Howard Sherman,** ARS.

John W. Cary, recently retired, was at the USDA-ARS Snake River Conservation Research Center, Kimberly, ID 83341. ■

Asthma Symptoms Eased by Vitamin B-6

Controlled dosages of vitamin B-6 alleviate shortness of breath and other symptoms of bronchial asthma, according to preliminary findings of USDA Agricultural Research Service and Columbia University scientists.

In a 2-year study, a 100-milligram oral dose of the vitamin was given daily to 15 asthma patients. All experienced fewer and less severe attacks, says Robert D. Reynolds, an ARS chemist.

"For the first time, we have confirmed that blood of adult asthma sufferers is low in vitamin B-6," Reynolds says. "Our preliminary

results show a relationship between very low levels of the vitamin and asthma." Other researchers had previously theorized that vitamin B-6 deficiency might be a factor in asthma attacks.

Reynolds cautions that vitamin B-6 is not a cure for asthma. The normal dietary intake of vitamin B-6 is 1.5 to 2.0 milligrams a day, and indiscriminate use of higher doses of the vitamin may lead to serious nerve damage. The daily 100-milligram doses used in the study, he stresses, were given only under a physician's care.

About 9 million people in the United States suffer from some form of asthma, an ailment that costs them over $1 billion a year for prescriptions and over-the-counter drugs.

Reynolds and co-researcher Clayton L. Natta of Columbia University in New York uncovered the asthma/vitamin B-6 link during a study of sickle cell anemia patients. (See *Agricultural Research,* Vol. 33, No. 1, Jan. 1985, p. 4)

In that study, much to their surprise, they found some of the group not suffering from sickle cell anemia had lower vitamin B-6 levels than the sickle cell anemia patients.

A search of their medical backgrounds revealed that all of them suffered from bronchial asthma, a fact unknown to the researchers before the study began.

Natta carried out the vitamin B-6 and asthma tests at Columbia University-affiliated hospitals in New York. He directed the vitamin dosages and blood sampling, and Reynolds performed the laboratory analyses.

Further research on the effects of vitamin B-6 on asthma is being carried out in cooperation with Ronald Simon of Scripps Clinic, La Jolla, CA. The study involves 45 adults and will continue for 2 years. "These studies should tell us if our preliminary results are valid," Reynolds says.—By **Vince Mazzola,** ARS.

Robert D. Reynolds is at the USDA-ARS Vitamin and Mineral Nutrition Laboratory, Beltsville Human Nutrition Research Center, BARC-East, Beltsville, MD 20705. ■

Brownies With Fewer Calories

Weight-conscious people may someday be able to enjoy less fattening cakes, brownies, and donuts, thanks to a no-calorie, high-fiber supplement developed by USDA's Agricultural Research Service.

The substance is a naturally occurring combination of cellulose and hemicellulose, two building blocks of plant cell walls. It can be prepared from a variety of sources—such as bran or straw from wheat, oats, and corn—by treating these materials with a dilute solution of hydrogen peroxide under special conditions.

The resulting fluffy fibrous material combines with other food ingredients, such as flour, much more readily than does untreated bran or other fiber supplements, according to chemist J. Michael Gould, who developed the process.

Research by Gould and biological technician Lee B. Dexter indicates that the fiber supplement could replace some of the flour used in baked goods, prepared mixes, and other foods without changing taste and texture. It could also be used as a thickening agent in instant drink mixes, milk shakes, and jelled foods.

The fiber is comparable to that found in wheat bran, but its baking properties are much better: While adding bran can cause bread loaves to rise less, peroxide-treated fiber is readily absorbed into batters and doughs without reducing baked volume.

In laboratory experiments, Gould and chemical engineer Brian K. Jasberg found that they could make a white bread that looks, feels, and tastes like any other white bread but contains as much fiber as whole wheat bread. Ordinarily, white bread has about a third as much dietary fiber as whole wheat bread.

Chemist J. Michael Gould, in laboratory kitchen, points to cake in which 20 percent of the flour was replaced with treated wheat straw. Next to it, a cake made with ordinary flour. The additive could provide more fiber and fewer calories in baked goods. (0986X1021-21A)

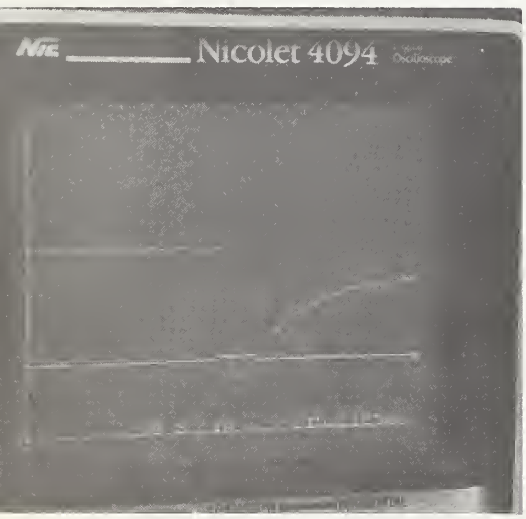
For example, they replaced 10 percent of the flour in a 1-pound loaf of bread with treated fiber from corn plants. The high-fiber bread contained about 14 percent fewer calories than white bread.

Gould and Jasberg have also incorporated treated fiber into normally calorie-rich, low-fiber foods such as cakes. A slice of their chocolate cake contains about as much fiber as a plate of lettuce and has 25 percent fewer calories than ordinary chocolate cake.

USDA is currently seeking a patent for the process.—By **Ben Hardin** and **Caree Lawrence,** ARS.

J. Michael Gould, Lee B. Dexter, and Brian K. Jasberg are located at the USDA-ARS Northern Research Center, 1815 North University Street, Peoria, IL 61604. ■

Electrical Probes Reveal How Insects Smell



Top: ARS entomologist Eric Jang inspects fruit fly trap on papaya tree. He is currently testing new synthetic odors in hopes of learning more about how insects perceive sensory stimuli such as odors. (0486X518-16A)

Above: Oscilloscope reading of electroantennograms. Sharp drop in top tracing shows that insect has responded to odor. Bottom tracing indicates length of exposure to stimulus. (0486X520-13)

Tiny probes inserted into the antennae of insects may reveal how these pests find and home in on the scents of ripening fruit or other crops they attack.

Scientists at USDA's Agricultural Research Service are using these delicate electrical probes to study the Mediterranean fruit fly (medfly), the boll weevil, and more than a dozen other voracious agricultural pests.

Such crop-damaging pests, like other insects, don't have noses that detect odors, so they rely primarily on their antennae for their sense of smell, says Eric B. Jang, an ARS entomologist in Hilo, HI.

Once Jang inserts the probes, they record electroantennograms—readings on the TV-like screen of an oscilloscope—that indicate whether the medfly can detect a specific odor. It may be the natural scent of ripening fruit or of a prospective mate or some other smell in the medfly's world.

"We puff an experimental odor near the insect," he says. "The probes will pick up even the slightest electrical response from the insect's supersensitive antennae."

Agency scientists cooperating in the medfly research, entomologists Joseph C. Dickens in Mississippi and Douglas M. Light in California, take electrical recordings of a different type—from individual nerve cells in the antenna or from single nerve cells in the brain.

But the goal of the three scientists is the same: To devise powerful new ways to disrupt the medfly's seemingly unerring ability to use chemical communication for finding potential mates and to respond to fruit odors in finding egglaying sites in susceptible crops.

According to Jang, besides their use for understanding how fruit flies perceive odors, electroantennograms offer other promising possibilities for future strategies to control the medfly.

Electrical responses might someday be used to identify harmless compounds that could be applied to crops to confuse and deceive the insects and thus protect fruits they would otherwise attack.

"The female fruit fly will attack certain fruits only when conditions are right for laying eggs inside the fruit," Jang says. "This means that the fruits must be at just the right stage of ripeness. What if we could confuse flies—and protect the crops—by spraying the ripening fruits with a harmless scent of unripened fruit?"

"What if we could confuse medflies—and protect the crops—by spraying ripening fruit with a harmless scent of unripened fruit?"

—**Eric B. Jang,** ARS entomologist

Electroantennograms were developed in the mid-1950's by a German scientist. They were followed by increasingly sophisticated variations—such as single-cell recordings.

At the agency's Boll Weevil Research Laboratory, Mississippi State, MS, Dickens is one of only a few scientists in the world who use single-cell recordings from the antenna.

Unlike Jang's work, which provides information about the antenna as a whole, Dickens records an individual olfactory nerve cell's response to specific scents. These cells are housed within thousands of hairs that make up the antenna.

Dickens relies on probes that are even finer than the ones Jang uses. He carefully positions them into the base of individual hairs, as close as possible to the nerve cells.

"Each olfactory nerve cell may have a specialized role in detecting specific scents," he says. "Cells in any given hair are well insulated from cells in other hairs and so react independently."

When an olfactory nerve cell

responds to a specific scent, it sends a signal, along a fiber called an axon, to the brain. For example, some signals may indicate to the female medfly that conditions on a fruit are right for her to begin laying her eggs within the fruit.

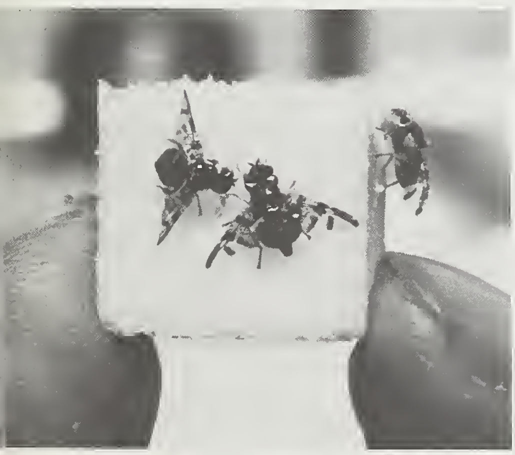
It is the insect's brain that integrates the incoming signals, says Light, at the ARS Western Research Center in Albany, CA. He inserts probes in specific regions of the insect's brain.

"We use these recordings to learn how the individual brain nerve cells receive and process the incoming information about scents from the olfactory nerve cells of the antennae," he says.

Light will be studying extremely small nerve cells within the medfly's very tiny brain. "Because the medfly's brain is about 20 times smaller than that of a large moth, medfly recordings could be very difficult to make."

"Our intent is to take what we learn and use it against insects that cost farmers money," Jang says.—By **Marcia Wood,** ARS.

Eric B. Jang is at the USDA-ARS Tropical Fruit and Vegetable Research Laboratory, Hilo, HI 96720. Joseph C. Dickens is at the USDA-ARS Boll Weevil Research Laboratory, Mississippi State, MS 39762. Douglas M. Light is at the USDA-ARS Western Research Center, Albany, CA 94710. ■



Above: Long hairs on antennae of male southwestern cornborer sense sex attractants, or pheromones, sent out by female cornborer. Magnified about 700 times. SEM by Joseph Dickens. (PN-7210) 100

Left: Mediterranean fruit flies (medflies) are among the leading pests of tree fruit in the United States and abroad. (0486X518-7A)

Top right: Each medfly antenna is a forest of hairs, called sensilla, which house olfactory nerve cells. Single-cell recordings from these cells reveal how they respond to specific scents. Magnified 2,700 times. SEM by Joseph Dickens. (PN-7211)

New Peach Unmarked by Leaf Spot Disease

Peach growers, and peach eaters, should be pleased that Freddi A. Hammerschlag has beaten the odds.

Out of 3 million peach cells taken from immature seeds of the Sunhigh variety, she found two cells that fight off bacterial leaf spot. Leaf spot, caused by the bacterium *Xanthomonas campestris pv. pruni,* is one of the fruit's worst diseases. From these two cells, she grew two plants that were significantly more resistant to leaf spot than any known resistant variety she tested.

The odds against finding mutant plants were extremely slim, but she improved her chances by using tissue culture techniques to screen large numbers of cells. Tissue culture is a way of keeping plant cells, tissues, and organs alive in laboratory dishes with a mix of nutrients and hormones.

Hammerschlag took less than a year to find the mutants by repeatedly exposing the peach cells to leaf spot toxin and then growing the survivors in nutrient-filled jars.

"I started with 400 clumps of peach embryo tissue, each containing thousands of cells," says Hammerschlag. "The two surviving cells came from a total cell population of around 3 million. It is impossible to do selection work with that many plants in a field or greenhouse."

Hammerschlag mixed the toxin from leaf spot bacterium into a growth medium for the 400 clumps. After several weeks of exposure, most of them turned brown, but tiny swellings of new growth appeared from within two of the clumps. Several more weeks of encouraging this new growth with hormones provided the scientist with two highly resistant shoots, which she then cloned into many more plants.

"It's the first time we've produced in the laboratory a disease-resistant woody plant from cells that came from a disease-susceptible variety," she says.

Over the next 2 years, young trees will be transplanted to orchards in North Carolina. Field tests there will show if the test-tube trees are indeed resistant outside of the laboratory.

Leaf spot is a major disease of East Coast peach orchards, and there is no effective pesticide. In damaging Sunhigh trees in commercial orchards, the disease keeps one of the best peaches off grocers' shelves, in Hammerschlag's opinion, which is backed by a USDA study of fruit quality.

"It's the first time we've produced in the laboratory a disease-resistant woody plant from cells that came from a disease-susceptible variety."

—**Freddi A. Hammerschlag,** ARS plant physiologist

If she has indeed beaten the odds against finding a resistant mutant, her technique may benefit growers of crops other than peaches. Disease pathogens of many other woody plants use toxins to break into plant tissue and steal nutrients. In the future, researchers may be able to rapidly select for resistance to these pathogens with a similar procedure.

For decades, Hammerschlag says, fruit tree breeders have focused on improving the fruit itself, how it tastes, appears, and keeps. "Other important factors, such as disease resistance and cold tolerance have been neglected."

Hammerschlag cautions that if the North Carolina field tests confirm the resistance, peaches from the new trees will still have to be studied for market qualities.—By **Stephen Berberich,** ARS. 100

Freddi A. Hammerschlag is at the USDA-ARS Tissue Culture and Molecular Biology Laboratory, BARC-West, Beltsville, MD 20705. ■

Above: Plant physiologist Freddi Hammerschlag displays fruit of her labor—vial containing bacterial spot-resistant peach shoots grown from cells. (0985X998-29)

Left: Peach shoots in growth medium. The first whole trees will be field tested in North Carolina to determine degree of resistance to leaf spot bacterium. (0586X656-6A)

Far left: Biological laboratory technician Brenda Pressnall removes peach shoot tips from trees grown through tissue culture to be used for further cloning. (0986X1017-31A)

Tissue Culture for Fast Growth

Plant tissue culture is a laboratory technique by which whole plants or parts of plants can be quickly cloned from bits of tissue or individual cells. They are nurtured in a liquid or semi-solid medium containing minerals, vitamins, sugar, synthetic hormones, and sometimes antibiotics.

Tissue culture's big attraction for commercial propagators is the speed at which the plants multiply—a geometric progression as each plantlet is cut up into pieces that in turn produce more plantlets. Pecans, hazelnuts, almonds, pears, apples, sweet and sour cherries, nuts, peaches—it's hard to name a horticultural crop that hasn't been produced by a commercial tissue culture lab, although total production remains far less than for conventional propagation methods.

Tissue culture is essential in research using genetic engineering and other biotechnologies, because it is the way altered cells can be increased in number in a short time.

In some cases, tissue culturing provides both the quickest and most reliable way to propagate a crop.

For example, it was a natural choice for Sri Lanka when the search began for a fast way to replace its aging tea orchards—some of them a century old. Conventional propagation techniques would take too long. They couldn't afford to wait that long for new orchards to produce Ceylon tea, a crop important to the island's economy.

In 1985, Sri Lanka requested Freddi A. Hammerschlag, a plant physiologist with the Agricultural Research Service, to assist them in renewing their tea orchards. Since her visit, Sri Lanka has sent four of their scientists to work on micropropagation techniques with Hammerschlag at the ARS Tissue Culture and Molecular Biology Laboratory in Beltsville, MD.

In addition to tea, Sri Lanka hopes to improve propagation of plants for coconut, rubber, cinnamon, and spices.—**D.C.** ■

Flight Tests Show How Wasps Locate Prey

Insects buzz around and zigzag through the air in a way that's far more systematic and predictable than one might think. For over 2 years, W. Joe Lewis and Michael A. Keller of USDA's Agricultural Research Service have been studying the flight patterns of females in a certain wasp species with the meticulous concentration of pro football coaches analyzing the moves of an elusive wide receiver.

"I guess that might be an apt comparison," says Lewis. "We use stop watches and video equipment, and we replay the tapes over and over again and chart each move the wasp makes. But there is one big difference.

"We aren't trying to stop the wasp. As a matter of fact, it's a good wasp to have around because instead of stinging people, it attacks caterpillars that eat a lot of crops."

"It's a good wasp to have around because instead of stinging people, it attacks caterpillars that eat a lot of crops."

—W. Joe Lewis, ARS entomologist

Lewis and Keller want to know how beneficial insects like the wasp actually go about finding their prey. They say that artificially reared wasps brought into target areas often get discouraged while flying around because they can't detect enough signs of the insects they are hunting. Then they decide to leave the area and look elsewhere.

Understanding this behavior could eventually help farmers use these natural allies more effectively against the caterpillar and other destructive insect pests.

Flight chamber studies by Lewis and Keller at the agency's Insect Biology and Population Management Laboratory in Tifton, GA, show that the wasp flies specific and discernible routes. Such flight patterns enable it to detect odors created by caterpillars feeding on plants and to zero in on these odors.

"We have to know which odors are important to the wasp," says Lewis, "and flight patterns are telling us a lot. We know the wasp distinguishes odors during flight, and we can see her adjust her flight path according to air currents and the odors they carry."

Wasp flying toward caterpillar feeding on leaf of bean plant. Odors emitted by caterpillar during feeding serve as attractant to wasp. (0786X818-30A)

To know precisely which odors attract the wasp, Lewis and Keller work closely with ARS chemist James Tumlinson in Gainesville, FL. According to Tumlinson, the odor created by a caterpillar chewing into a leaf is chemically different from the odor of either an unbitten leaf or the odor of a caterpillar by itself.

Keller says, "Once we know the chemical makeup of each odor the wasp is pursuing—and the makeup of each odor she doesn't like—we should be able to significantly improve biological control programs in which the wasp is deployed."

Joining Lewis and Keller in their studies of the wasp are scientists from France and Holland, two of the European countries also studying ways to use this type of wasp.

The big obstacle to effective wasp deployment in both Europe and America is convincing wasps artificially reared in massive numbers to behave the way wasps reared in the wild do. "And it really is a matter of teaching them," says Keller.

ARS entomologist Joe Lewis (left) prepares to attract wasp by placing caterpillar larvae on bean plant while research associate Mike Keller gets ready to release wasp into flight cage. (0786X819-14)

"We can keep artificially reared wasps in the field where they're most needed," he says, "by exposing the wasps to the odors of caterpillars before releasing them. Then they'll know what to look for. And if the odors in the field aren't strong enough, we can add to them as well."—By **Steve Miller,** ARS.

W. Joe Lewis and Michael A. Keller are in the USDA-ARS Insect Biology and Population Management Laboratory, P.O. Box 748, Tifton, GA 31793-0748. ■

Choosy Soybeans Fix More Nitrogen

Soybean plants that prefer to root down with a better class of nitrogen-fixing soil bacteria are what geneticist Perry B. Cregan and microbiologist Harold H. Keyser want, and they are beginning to find them. The plants could help U.S. soybean farmers boost profits.

These USDA Agricultural Research Service scientists at the Nitrogen Fixation and Soybean Genetics Laboratory at Beltsville, MD, found 13 superior plants among 1,300 genetically different types of soybeans. During the 2-year search, they picked through uncounted soybean root systems to find signs of a more fruitful partnership between plant and bacteria.

Just below the surface of farm fields, dozens of strains of the soil bacterium *Bradyrhizobium japonicum* battle for the right to get inside soybean roots. And, say Cregan and Keyser, it's the soybean plant that appears to be in charge of which bacteria infect them.

Just below the surface of farm fields, dozens of strains of the soil bacterium* Bradyrhizobium japonicum *battle for the right to get inside soybean roots.

The root tissue somehow selects only specific strains of the bacteria which are then fed and housed in nodules formed on the roots in response to the infection. The bacteria return the favor by changing nitrogen from pockets of air in the soil into fertilizer that helps the plant grow.

Bradyrhizobium bacteria infect the tips of roots, then follow an infection thread created by invaginated, or infolded, plant cells. The nuclear DNA of the soybean seems to direct the penetration of the root tissue. By a yet unknown process, strains not favored by a particular plant fail to cause formation of nodules. Compounding the problem: The bacteria strains most favored by U.S. soybean varieties are weak in fixing nitrogen.

Early in the century, farmers would carry soil from one soybean field to the next and sprinkle it onto seeds before planting. This would ensure that the bacteria in the soil would fix nitrogen for their crop.

Since the 1940's, commercial peat and powder products containing the bacteria have been sold to farmers, who coat seeds with the products before planting.

Although research may be poised for genetic engineering of super strains of nitrogen-fixing bacteria for coating seeds, such strains will be useless if soybean varieties continue to form nodules only with inefficient strains already living in fields.

The strategy of Cregan and Keyser, therefore, is to make no further changes in the bacteria while they work on soybean plants with an exclusive preference for improved strains of nitrogen-fixing bacteria.

Significantly, the plants found so far tend to exclude strain USDA 123, a highly competitive but ineffective nitrogen-fixing bacterium that is solidly entrenched in midwestern soybean fields. Six midwestern states produce more than 60 percent of the U.S. soybean crop each year.

Cregan thinks he and Keyser have uncovered two genes in the choosy plants that each command exclusion of some subgroups of USDA 123 bacteria. Their goal is to identify genes that exclude all the subgroups.

So far, 13 types of soybean plants of 1,300 screened exclude some USDA 123 bacteria. However, there are 10,000 to 12,000 genetically different types of soybean plants known, so the scientists have their work cut out for them.

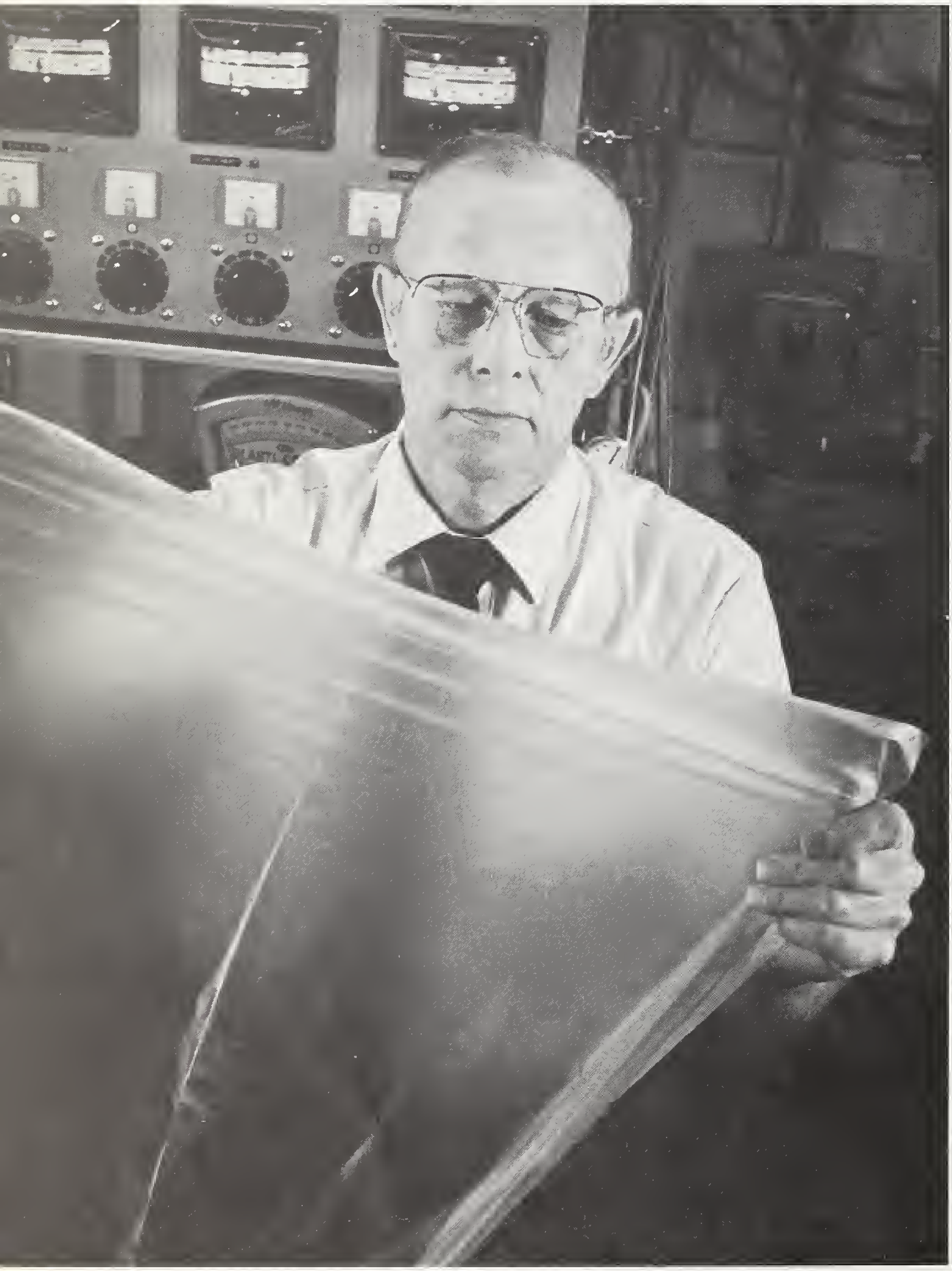
The world's largest repositories for soybean plant material are ARS facilities at Stoneville, MS, and Urbana, IL. Scientists at both locations are supplying Cregan and Keyser with seeds for their experiments.

The laboratory's newest member, molecular geneticist Michael J. Sadowsky, will spearhead the first effort to unravel the genetic control of nodulation by *Bradyrhizobium* USDA 123.

Over the next 2 years, Cregan, Keyser, and Sadowsky will further study choosy genes in soybeans with the help of a grant from USDA's Cooperative Grants Program.—By **Stephen Berberich,** ARS.

Perry B. Cregan, Harold H. Keyser, and Michael J. Sadowsky are at the USDA-ARS Nitrogen Fixation and Soybean Genetics Laboratory, HH-19, Range 1, BARC-West, Beltsville, MD 20705. ■

Farm Surpluses: Sources for Plastics



ARS chemist Felix Otey displays large sheets of plastic film, made from starch and petroleum-based polymers, which were processed on a commercial extrusion blowing machine. (0986X1019-6)

Starch from corn may soon replace petrochemicals in plastic films. And glycerol—a byproduct from processing of animal fats, soybeans, and other vegetable oil crops—may one day compete with petrochemicals in acrylic plastic manufacturing.

These are two examples of how research may help convert the nation's surplus farm commodities into needed industrial products.

Studies at the USDA Agricultural Research Service center in Peoria, IL, show that starch can be blended into plastic films that may serve as biodegradable mulches for tomatoes and other high-value crops. "We are working on new formulas for mulches that micro-organisms can break down after a crop is harvested," says chemist Felix Otey.

This feature preserves the environment and saves the expense of having to remove and burn or bury the mulches.

Home gardeners and farmers use plastic mulches to protect crops from weeds and drought and extend the growing season by warming the soil sooner in the spring. And farmers use them to produce an earlier crop that commands a good price.

An estimated 285 million pounds of petroleum-based plastic film was produced in 1983 for agricultural use, according to an industry spokesman at a National Agricultural Plastics Association meeting. About 125 million pounds of that plastic was used for mulching. Total film production was projected at 423 million pounds by 1990, but Otey suggests the projection may prove too conservative as technology advances.

Starch-plastic blends have other potential applications. They could serve as wrappings for foods and other consumer items. They can be made into semipermeable membranes—films that allow small molecules in a mixture to pass through them while retaining larger molecules. These membranes could serve a myriad of uses, such as separating toxic substances from blood in artificial kidneys and recovering lye used in manufacturing rayon.

Research started more than a decade ago by Otey and colleagues led to the only starch films produced commercially thus far: water-soluble laundry bags for use in hospitals. These bags can be sealed and placed directly into the washing machine where they dissolve, protecting hospital staff against the danger of contamination from soiled linens.

Until now, other markets for starch films have not developed, probably because the formulations resulted in films that were too weak and had too many tears and other flaws. Industrial processes that turn out hundreds of feet of film per minute require a uniform, continuous film.

About 125 million pounds of petroleum-based plastic film was used for agricultural mulches in 1983.

—National Agricultural Plastics Association

Last year, a commercial firm ran one of Otey's new formulations through a film-blowing machine without any major problems. About 45 percent of the new formulation was ethylene acrylic acid (EAA) polymer, a compound that imparts uniform composition and strength to the film.

Using the recent technical advances, starch films could probably be produced and marketed at prices not much higher than prices for pure plastic ones, says Otey. And the difference could be offset by savings from not having to dispose of the mulch after use.

In a scenario in which costs of petrochemicals rise and price of corn remains depressed by surpluses, starch-plastic films may become more competitive with conventional films.

As of September 1, 1986, the nation had a surplus of about 2.5 billion bushels of corn. The oversupply is expected to grow to 3.5 billion bushels by the fall of 1987.

From Soybeans to Plastics

Scientists foresee potential new uses for soybeans and other vegetable oil crops as changing economics lead to adoption and refinements of research developments at the Northern Research Center.

Vegetable oils are candidates for alternative fuels for diesel engines, but they are too viscous, or syrupy, for direct use, says chemist Arthur W. Schwab. Having conducted research to overcome this problem, Schwab patented a method to use microemulsions of water and alcohol dispersed in vegetable oils as diesel fuel. And using another approach, chemist Bernard Freedman has chemically modified soybean oil to a fuel and a byproduct, glycerol.

Glycerol is also a common byproduct of both animal and vegetable fat processing. Someday, bacteria may play a role in converting abundant supplies of glycerol to acrylic plastics.

Chemical engineer Patricia J. Slininger of the Northern Research Center has cited the bacterium *Klebsiella pneumoniae* as a candidate for that role. In fermentations, it feeds on glycerol.

K. pneumoniae produces 3-hydroxypropionaldehyde (3-HPA) that converts to acrolein. Acrolein can be used to make synthetic polymers, building blocks of such diverse products as clothing, acrylic plastics, pharmaceuticals, and paints.

Acrylic acid derived from acrolein and used in some of the products is worth about 60 cents per pound. Billions of pounds are produced each year, and each pound is made from about 3 pounds of petroleum.

Slininger and microbiologist Rodney J. Bothast found that in batches of fermentation broth *K. pneumoniae* can convert up to 84 percent of glycerol into 3-HPA, the parent compound of acrolein and acrylic acid. They and James E. Van Cauwenberge have patented the process. *(See page 16.)*

Could the research quickly lead to added value for surplus farm commodities? "That's not likely soon because the economics of replacing petroleum-

Chemical engineer Pat Slininger draws sample of fermentation broth from biostat fermenter, an instrument which can convert glycerol to compounds used in manufacturing synthetic polymers. (0986X1020-7)

derived acrylic acid are not yet favorable," says Bothast. "But when the time is right, what we have learned will be ready and waiting for commercial use, with some technical refinements."

Looking into their crystal ball, the scientists foresee starchy farm products such as grain or cellulosic products such as cornstalks also serving as raw material for acrylic plastics. There are micro-organisms that produce glycerol during the fermentation of these materials to alcohol, Bothast says.

Bothast's research group is conducting basic research on the microbiology, physiology, and genetics of micro-organisms involved in fermentation. What they learn may someday have application in enzyme technology and biochemical engineering aimed at increasing the efficiency of meat and milk production and converting agricultural commodities into new and improved products.—**Ben Hardin**, ARS. 100

The scientists mentioned in this article are at the USDA-ARS Northern Research Center, 1815 North University, Peoria, IL 61604. ■

X-Ray System Finds Contraband Fruit, Plants

The airline passenger insisted that the cardboard box he was carrying didn't have any food in it.

But the agricultural inspector responsible for nabbing contraband foods and plants before they get any farther than the agricultural checkpoint at San Francisco International Airport, wasn't so sure.

Earlier, this box—and hundreds of others parcels and suitcases from incoming planes—had been tagged and routed through an experimental video, X-ray, and computer system that was specially programmed to detect food in luggage. The tag on this particular box indicated that "food shapes" had been spotted inside it and that it should be searched.

The inspector turned to a TV screen and called up from the computer's memory the X-ray image of the box taken a half-hour earlier.

With this, she knew exactly where to look inside the box and what to look for. Her find: A bag full of mangoes. She sliced one open and found the wriggling, wormlike larva of a mango seed weevil.

The passenger left without the fruit and with a warning against trying to smuggle illegal food into the country. He wasn't fined, but he could have been. The U.S. Government has collected more than $1 million in agricultural fines since 1984.

In this and similar instances, the experimental system showed its ability to help agricultural inspectors quickly and easily locate forbidden foods in the stream of suitcases, duffle bags, boxes, and parcels passengers bring with them from overseas flights.

So far, tests this past summer at San Francisco's airport turned up such illegal items as coconuts, dried orange peels, fresh mangoes hidden in large tin cans, and partially cooked duck eggs, according to the system's developers, chemist Thomas F. Schatzki and engineer Richard Young. Both are with USDA's Agricultural Research Service at the Western Research Center in Albany, CA.

Tests of the X-ray detection system this past summer at San Francisco's airport turned up such illegal items as coconuts, dried orange peels, fresh mangoes hidden in large tin cans, and partially cooked duck eggs.

Thomas Schatzki of ARS, seated at his X-ray device for detecting contraband fruit, marks a bag for inspection while U.S. Customs officer Don Patchen checks it for weapons and other illegal items. (0886X1003-21)

The system, developed for USDA's Animal and Plant Health Inspection Service (APHIS), could streamline manual inspection by—

- Alerting inspectors to those bags that need to be searched by hand, and thus eliminating the need to hand-search hundreds of other bags that are free of contraband.
- Showing where in these bags passengers might have packed the food.

Certain unprocessed foods and plants from other countries are banned in the United States because they may contain foreign insects or disease organisms that could wipe out American crops or livestock. The confiscated duck eggs, for example, might carry Newcastle disease, deadly to poultry. Orange peels might harbor citrus canker that could infect U.S. citrus groves.

Schatzki says the patented system

uses off-the-shelf digital X-ray equipment, a video monitor, and computers to find contraband. Here's how it works:

As luggage is unloaded from a plane, it is given a numbered tag, then routed past X-ray equipment that creates a picture of what's inside the bag. This X-ray image is fed to a TV screen and to a computer, where it is instantly analyzed and stored.

The computer is programmed to recognize what Schatzki describes as "food shapes." Specifically, the computer can readily locate the circular cross-sections that almost unfailingly distinguish food and other agricultural items from manufactured objects (which usually have rectangular cross-sections).

On the TV screen, any food shapes recognized by the computer are instantly highlighted by a brightly colored outline.

At that point, the numbered tag on the suspect luggage is specially marked. Later, when the traveler picks up the luggage and takes it to the checkout stations, the code will alert other inspectors that the luggage must be hand-searched.

"The video and X-ray can scan the bags at the rate of about one bag every 3 seconds," Schatzki says. "The computerized system could cut the time passengers spend waiting in line and still give APHIS inspectors at least a glance in every bag."—By **Marcia Wood,** ARS.

Thomas F. Schatzki and Richard Young are at the USDA-ARS Western Research Center, 800 Buchanan St., Albany, CA 94710. ■

Test for Spoilage in Liquid Eggs

Food inspectors rely mostly on odor to tell if liquid eggs, used for commercial baking, are spoiled. Now food quality scientists have found a chemical test to detect spoilage.

An analytical process, chromatography, measures two chemical substances that are present at higher levels in spoiled liquid eggs, says Cletus E. Morris, a chemist for USDA's Agricultural Research Service.

Morris and Mona L. Brown, also a chemist at the agency's Southern Research Center in New Orleans, LA, found that if the two chemicals—dimethyl sulfide and uracil—are at higher-than-minimum levels in liquid eggs, inspectors usually find the eggs unfit to eat.

Morris says results to date indicate that the new test offers a precise, objective way to monitor liquid eggs, "especially when they are just on the verge of spoiling. At that point, inspectors may not be able to smell the odor even though the eggs are beginning to spoil."

Liquid eggs are removed from shells at processing plants and shipped in bulk on refrigerated tank trucks. They are used as ingredients for baked goods, custards, and other foods. The new test would not be used for eggs in their shells.

In addition to checking for spoilage by evaluating odor, inspectors at egg-processing plants routinely screen eggs by using bacteriological tests, Brown says.

The new test, if confirmed by further evaluation, would be a faster and simpler way to detect spoilage and could be adapted for on-the-spot use, Morris says. He and Brown did the research in the center's food flavor quality laboratory.

They used two types of chromatography—liquid and gas—to check egg batches. Morris relied on the liquid form to analyze whole eggs and yolk samples for uracil, an odorless chemical compound. Brown used gas chromatography to detect dimethyl sulfide, a volatile substance, in samples of whole eggs, yolks, or egg whites.

Dimethyl sulfide is a liquid found in a number of natural products. In trace amounts, it can give a desirable flavor, but in large amounts it may contribute to the smell of the spoiled eggs. The researchers say that it is not known what causes the higher amounts of dimethyl sulfide and uracil in spoiled liquid eggs.—By **Sean Adams,** ARS.

Cletus E. Morris and Mona L. Brown are at the USDA-ARS Southern Research Center, P.O. Box 19687, New Orleans, LA 70179. ■

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PATENTS

Plant Fiber Additive for Food

See "Brownies With Fewer Calories," p. 5. *Patent Application Serial No. 06/809,803, "Modified Plant Fiber Additive for Food Formulations."* ■

Turning Surplus Crops Into Plastics

See "Farm Surpluses: Sources for Plastics," p. 13. *Patent No. 4,454,268, "Starch-Based Semipermeable Films"; Patent No. 4,337,181, "Biodegradable Starch-Based Blown Films"; and Patent Application Serial No. 894,140, "Production of 3HPA From Glycerol by* Klebsiella pneumoniae." ■

Detection of Agricultural Contraband

See "X-Ray System Finds Contraband Fruit, Plants," p. 14. *Patent No. 4,539,648, "Detection of Agricultural Contraband in Luggage."* ■

Computerized Windmills

Wind-driven generators or alternators can generate 29 to 47 percent more power with this computerized control system than machines with older control methods.

The new system makes adjustments to maximize electricity production based on the output voltage of the generator. (Output voltage is related to the rotational speed of the generator and thus to windspeed.)

A sensor periodically samples the output voltage while a computerized control increases voltage to the generator field coils a step at a time. After each increase, the computer checks to see if overall output is still going up. As soon as the output starts to decrease—such as with a drop in windspeed—the computer lowers the field voltage step by step to keep electrical output as high as possible for the available wind.

In this way, the computer responds to changes in windspeed, giving the turbine maximum performance.

Another sensor measures windspeed directly, to turn off the turbine if there is too little wind to operate efficiently or if speeds become dangerously high.

Patent Application Serial No. 06/680,615, "Output Responsive Field Control for Wind-Driven Alternators and Generators." ■

Detecting Immunoglobulins in Swine

An Agricultural Research Service scientist has developed an accurate way to detect and measure swine antibodies—proteins that transmit immunity to offspring.

This discovery has implications for human research because pigs are research models for similar immune systems in people.

Detection of these proteins, immunoglobulins (Ig's), also holds considerable potential for diagnosis of swine diseases. This detection method uses monoclonal antibodies specific to each of three major types of Ig's (IgM, IgG, and IgA). IgM is the first and main Ig produced by a pig's immune system to ward off a disease. As the attempt to fight infection progresses, IgG is produced and the IgM level goes down. The ability to identify and measure amounts of IgM could therefore be useful to distinguish current from past infections. Antibodies to IgA will provide tools for detecting Ig's in secretions and be useful in studies on immunity to enteric (small intestine) pathogens.

Patent No. 4,468,346, "Monoclonal Antibodies to Porcine Immunoglobulins." ■

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